REMARKS

Applicants appreciate the detailed examination evidenced by the Official Action mailed January 25, 2005 (hereinafter the "Official Action"). Applicants also appreciate the allowance of Claim 18 and the further indication that Claims 3, 4, 15 and 16 would be allowable if rewritten in independent form and to overcome the objections thereto in the Official Action. *Official Action, page 3.* In response, Applicants have amended Claims 5-7 as suggested by the Examiner. Applicants have similarly amended Claims 11 and 12 to correct typographical errors therein.

As discussed herein below in greater detail, Applicants respectfully maintain that Claims 1, 2, 5-14 and 17, as written, are patentable over the cited references for at least the reasons discussed herein.

Independent Claims 1 and 7 are patentable over Iizuka

Claims 1, 2, 7-10, 13, 14, and 17 stand rejected under 35 U.S.C. § 102 over U.S. Patent Application Publication No. 2002-0190294, to Iizuka et al. ("Iizuka"). *Official Action, page 2.* Applicants respectfully submit that Iizuka does not disclose all the recitations of independent Claim 1 which recites in-part:

> **crystallizing an HfO_2 dielectric layer on a lower electrode of a capacitor structure in a low temperature plasma treatment at a temperature in a range between about 250 degrees Centigrade and about 450 degrees Centigrade**; and
>
> forming an upper electrode on the HfO_2 dielectric layer. Independent Claim 7 includes similar recitations.

Independent Claim 7 includes similar recitations.

Anticipation under § 102 requires that each and every element of the claim is found in a single prior art reference. *W. L. Gore & Associates Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1554, 220 U.S.P.Q. 303, 313 (Fed. Cir. 1983). Stated another way, all material elements of a claim must be found in one prior art source. *In re Marshall*, 198 U.S.P.Q. 344 (C.C.P.A 1978). "Anticipation under 35 U.S.C. § 102 requires the disclosure in a single piece of prior art of each and every limitation of a claimed invention." *Apple Computer Inc. v. Articulate Systems Inc.* 57 USPQ2d 1057, 1061 (Fed. Cir. 2000). A finding of anticipation further requires that there must be no difference between the claimed invention and the disclosure of

the cited reference as viewed by one of ordinary skill in the art. See *Scripps Clinic & Research Foundation v. Genentech Inc.*, 927 F.2d 1565, 1576, 18 U.S.P.Q.2d 1001, 1010 (Fed. Cir. 1991). Additionally, the cited prior art reference must be enabling, thereby placing the allegedly disclosed matter in the possession of the public. *In re Brown*, 329 F.2d 1006, 1011, 141 U.S.P.Q. 245, 249 (C.C.P.A. 1964). Thus, the prior art reference must adequately describe the claimed invention so that a person of ordinary skill in the art could make and use the invention.

Applicants respectfully submit that Iizuka does not disclose, for example, **crystallizing an HfO_2 dielectric layer on a lower electrode of a capacitor structure in a low temperature plasma treatment at a temperature in a range between about 250 degrees Centigrade and about 450 degrees Centigrade**. In particular, the cited passages of Iizuka read:

> An interlayer insulator film **103** is formed to cover an uppermost interconnection (ground line) **101**, another uppermost interconnection (power supply line) **102** and an underlying interlayer insulator film. On the interlayer insulator film **103**, a lower electrode **105**, a capacitor dielectric film **106** and an upper electrode **107** are formed in the named order to constitute a decoupling capacitor **104**. The lower electrode **105** is connected through a contact **108** to the uppermost interconnection (ground line) **101**, and the upper electrode **107** is connected through a contact **109** to the uppermost interconnection (power supply line) **102**. *Iizuka, page 8, paragraph 131.*

> Thereafter, a capacitor dielectric film is deposited to cover the lower electrode **105** by use of the ALD process at a film deposition temperature of 200 to 400 degrees Celsius. This capacitor dielectric film is constituted of a single-layer film formed of at least one material selected from the group consisting of ZrO_2, HfO_2, $(Zr_x, Hf_{1-x})O_2$ $(0<x<1)$, $(Zr_y, Ti_{1-y})O_2$ $(0<y<1)$, $(Hf_z, Ti_{1-z})O_2$ $(0<z<1)$, $(Zr_k, Ti_i, Hf_m)O_2$ $(0<k, 1, m<1, k+l+m=1)$, or alternatively, a multi-layer film formed of at least two materials selected from the group mentioned above. Then, the capacitor dielectric film is patterned into a desired shape to form the capacitor dielectric film **106**. *Iizuka, page 8, paragraph 134.*

As understood by Applicants, the above-cited passages of Iizuka do not disclose "crystallizing an HfO_2 dielectric layer...in a low-temperature plasma treatment." Independent Claims 1 and 7. In fact, the above-cited passages of Iizuka do not even mention crystallization or a plasma. The cited passages of Iizuka appear to be a discussion of the

fourth embodiment therein which focuses on **avoiding** crystallization by forming the dielectric layer using atomic layer deposition:

> As mentioned above, in the fourth embodiment, since a capacitor dielectric film having a high dielectric constant is formed by the ALD process which can carry out a film deposition at a low temperature and **which makes the post-anneal in an oxidizing atmosphere unnecessary**, the thin film capacitor can be formed in the semiconductor device with no characteristics deterioration attributable to oxidation of the interconnection layer and with no drop in yield of production. *Iizuka, page 9, paragraph 138 (emphasis added).*

As understood by Applicants, the above-cited passage of Iizuka teaches away from the recitations of independent Claim 1 by claiming that forming a dielectric layer using ALD makes a post-anneal unnecessary. Accordingly, the portions of Iizuka cited in the Official Action do not disclose or suggest, at least, "**crystallizing an HfO_2 dielectric layer on a lower electrode of a capacitor structure in a low temperature plasma treatment at a temperature in a range between about 250 degrees Centigrade and about 450 degrees Centigrade**." Independent Claims 1 and 7.

Furthermore, the remainder of Iizuka also does not disclose or suggest the use of a plasma to crystallize an HfO_2 dielectric layer. In fact, as understood by Applicants, all of the other embodiments discussed in Iizuka discuss the use of a thermal anneal to process the dielectric, not a plasma treatment. Accordingly, as understood by Applicants, Iizuka does not disclose, at least, **crystallizing an HfO_2 dielectric layer on a lower electrode of a capacitor structure in a low temperature plasma treatment at a temperature in a range between about 250 degrees Centigrade and about 450 degrees Centigrade**.

As further evidence of the failure of Iizuka to disclose or suggest the use of a plasma treatment to crystallize the HfO_2 dielectric layer:

> It could be seen from **FIG. 6** that the case of carrying out the anneal under the mixed gas of hydrogen and nitrogen and the case of carrying out the anneal under only the nitrogen exhibit substantially the same leakage current value. **Therefore, it would be seen that only the heat treatment is effective, and the atmosphere for the anneal does not give any influence**. *Iizuka, page 5, paragraph 81, last two sentences (emphasis added).*

As demonstrated by the above-cited passage of Iizuka, even the embodiments discussed therein that include an anneal process teach away from using a plasma as the

discussion related to the atmosphere for the anneal explicitly states that "only heat treatment is effective" and the atmosphere in which the anneal is performed "does not give and influence".

In view of the above, Applicants respectfully submit that independent Claims 1 and 7 are patentable over Iizuka. Furthermore, dependent Claims 2, 8-10, 13 and 14 are patentable at least per the patentability of independent Claim 1 as described above.

The Claims are patentable over Iizuka in view of Harada.

Claims 5, 6, 11, and 12 stand rejected under 35 U.S.C. § 103 over Iizuka in view of U.S. Patent Application Publication No. 2002-0195643 to Harada ("Harada"). *Official Action, page 3.* In addition to the reasons discussed above with reference to Iizuka, Applicants further submit that Harada also does not disclose or suggest the teachings shown above to be missing from Iizuka.

To establish a *prima facie* case of obviousness, the prior art reference (or references when combined) must teach or suggest all the claim limitations. Furthermore, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings, and there must be a reasonable expectation of success of the combination. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. See MPEP § 2143. As stated by the Court of Appeals for the Federal Circuit, to support combining references in a § 103 rejection, evidence of a suggestion, teaching, or motivation to combine must be clear and particular, and this requirement is not met by merely offering broad, conclusory statements about teachings of references. *In re Dembiczak*, 50 USPQ2.d 1614, 1617 (Fed. Cir. 1999).

The Official Action cites paragraph 81 of Harada as disclosing annealing HfO_2 dielectric layer in a plasma atmosphere including N_2. However, paragraph 81 of Harada actually reads as follows:

> Herein, the thermal stability guarantee temperature refers to the annealing temperature at which a drastic increase of leak current starts to occur in an insulating film made of HfO_2 when an annealing treatment is performed with respect to a MOS capacitor structure having the insulating film for 30 seconds in

> N_2 gas at 1 atm with a rapid thermal process (RTP) apparatus. Therefore, at temperature below the thermal stability guarantee temperature, the leak current and the capacitance in the MOS capacitor structure employing the Si-containing HfO_2 film indicates an ideal value. On the other hand, at temperatures above the thermal stability guarantee temperature, the leak current in the MOS capacitor structure increases by about three orders due to a drastic increase of defects locally occurring in the Si-containing HfO_2 film. At this point, the capacitance in an accumulation state in a C-V (capacitance-voltage) measurement diverges, and therefore it becomes impossible to measure the capacitance of the MOS capacitor. In other words, at temperatures above the thermal stability guarantee temperature, the MOS capacitor structure employing the Si-containing HfO_2 film cannot serve as a capacitor. *Harada, page 5, paragraph 81.*

The above-cited passage of Harada does not even mention a plasma treatment. Moreover, the process discussed in the above-cited passage of Harada actually relates to silicon-containing HfO_2 dielectric layers, not to HfO_2 dielectric layers. Applicants respectfully submit that a disclosure of silicon-containing HfO_2 dielectrics is not equivalent to HfO_2. Accordingly, even if Harada and Iizuka were combined, the combination would not disclose or suggest all the recitations of the claims as required under section 103.

Furthermore, as understood by Applicants, one of the major issues discussed in Harada is the crystallization temperature and formal stability of HfO_2. In particular, Harada appears to discuss adding silicon to HfO_2 in order to stabilize the dielectric so that it may be subject to a thermal anneal while **reducing** the amount of crystallization created. For example, Harada reads as follows:

> As shown in **FIG. 2**, the crystallization temperature and the thermal stability guarantee temperature of HfO_2 increase with the ratio X_1, that is, the amount of added Si. In other words, the addition of silicon to HfO_2 increases the thermal stability of HfO_2. This is because an increase of the Si amount makes it easy that Si-containing HfO_2, **that is, a Hf silicate material remains amorphous, and as a result, the entire HfO_2 film hardly is crystallized and remains amorphous**. *Harada, page 5, paragraph 80 (Emphasis added).*

The above-cited passage appears to discuss adding silicon to HfO_2 to reduce the amount of crystallization that occurs therein as a result of the high temperature thermal anneal. In contrast, the present claims recite, for example, crystallizing an HfO_2 dielectric layer. As understood by Applicants, not only does Harada not disclose a number of recitations of the present claims, Harada actually teaches away from crystallizing an HfO_2 dielectric layer by

suggesting the inclusion of silicon so that the dielectric layer remains amorphous at higher temperatures. Accordingly, there is also no clear and particular evidence of a motivation or suggestion to combine the references as required under section 103 as the objectives (*e.g.*, crystallization v. non-crystallization) are at odds with one another. In view of the above, the present claims are patentable over Iizuka and Harada for at least the reasons discussed above.

New Claims 19 and 20 are Patentable

Applicants have also added new Claims 19 and 20 which are patentable over Iizuka and Harada. For example, new independent Claim 19 recites in-part:

> crystallizing an existing HfO_2 dielectric layer on a lower electrode of a capacitor structure in a plasma atmosphere at a temperature in a range between about 250 degrees Centigrade and about 450 degrees Centigrade; and
> forming an upper electrode on the HfO_2 dielectric layer.

As discussed above, Iizuka and Harada do not disclose a number of the recitations shown above. Accordingly, new independent Claim 19 is also patentable over Iizuka and Harada. Furthermore, new Claim 20 depends from new independent Claim 19 and is, therefore, patentable at least for the patentability of new independent Claim 19.

CONCLUSION

Applicants have shown herein that the present claims are patentable over Iizuka and Harada. Accordingly, Applicants respectfully request the withdrawal of all rejections and the allowance of all claims in due course. If any informal matters arise, the Examiner is encouraged to contact the undersigned by telephone at (919) 854-1400.

Respectfully submitted,

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